PATENT ABSTRACTS OF JAPAN

(11)Publication number : 09-130192

(43)Date of publication of application : 16.05.1997

(51)Int.Cl. H03H 9/145

(21)Application number : 08-228781

(22)Date of filing : 29.08.1996

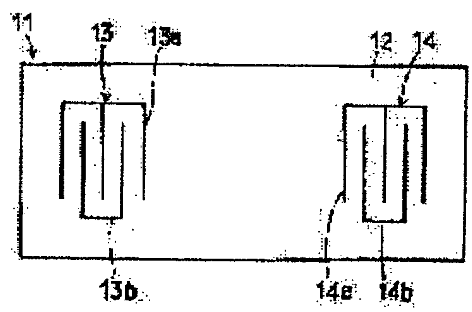
(71)Applicant : MURATA MFG CO LTD

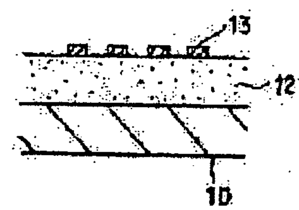
(72)Inventor : KADOTA MICHIO

(30)Priority

Priority number : 07225270 Priority date : 01.09.1995 Priority country : JP

(54) SURFACE WAVE DEVICE





(57)Abstract:

PROBLEM TO BE SOLVED: To improve the temperature characteristic and also to increase the electricity-machine coupling coefficient for a surface wave device by setting the normalized thickness of a piezoelectric thin film at the specific value or more.

SOLUTION: A ZnO thin film 12 is formed on the entire surface of a crystal substrate 10, and the IDT 13 and 14 are formed on the film 13 with a space secured between them. The IDT 13 and 14 include a pair of sawtooth electrodes 13a and 13b and 14a and 14b, respectively. When the film 12 is formed on the plate 10, the normalized thickness H/λ of the film 12 is desirably set at ≥ 0.05 (H, thickness of film 12; λ, surface wavelength). The electricity-machine coupling coefficient is usually reduced when the DIT is formed between the no film and the crystal. However, a large electricity-machine coupling coefficient is secured when the DIT 13 and 14 are formed on the film 12 like this example. Furthermore, the electricity-machine coupling coefficient is further increased when a short circuit electrode is inserted into the interface between the plate 10 and the film 12.

LEGAL STATUS

[Date of request for examination]	12.07.1999
[Date of sending the examiner's decision of rejection]	26.03.2002
[Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]	
[Date of final disposal for application]	
[Patent number]	3341596
[Date of registration]	23.08.2002
[Number of appeal against examiner's decision of rejection]	2002-07335
[Date of requesting appeal against examiner's decision of rejection]	25.04.2002
[Date of extinction of right]	

3

(19)日本国特許庁（ＪＰ） (12) 公開特許公報（Ａ） (11)特許出願公開番号

特開平9－130192

(43)公開日 平成9年(1997) 5月16日

(51)Int.Cl.⁶	識別記号	庁内整理番号	F I		技術表示箇所
H03H 9/145		7259－5J	H03H 9/145	C	

審査請求 未請求 請求項の数7 OL （全 10 頁）

(21)出願番号 特願平8－228781

(22)出願日 平成8年(1996) 8月29日

(31)優先権主張番号 特願平7－225270

(32)優先日 平7 (1995) 9月1日

(33)優先権主張国 日本（ＪＰ）

(71)出願人 000006231
株式会社村田製作所
京都府長岡京市天神二丁目26番10号

(72)発明者 門田 道雄
京都府長岡京市天神二丁目26番10号 株式会社村田製作所内

(74)代理人 弁理士 宮▼崎▲ 主税 （外1名）

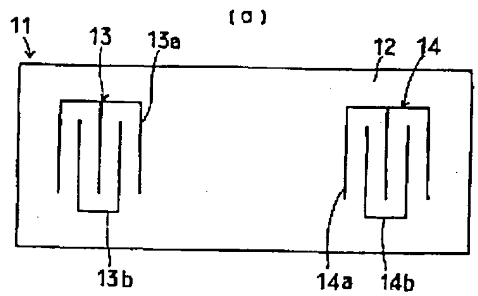
(54)【発明の名称】 表面波装置

(57)【要約】

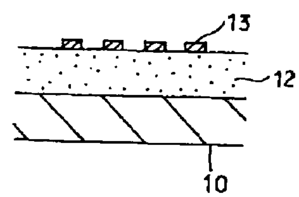
【課題】 水晶基板を用いて従来より電気機械結合係数が大きいＳＡＷ装置提供する。

【解決手段】 水晶基板１０上にＺｎＯ薄膜１２を形成し、ＺｎＯ薄膜１２上にくし歯電極１３ａ，１３ｂ，１４ａ，１４ｂを形成してなり、ＺｎＯ薄膜１２の規格化膜厚Ｈ／λを０．０５以上としたＳＡＷ装置。

(a)



(b)



【特許請求の範囲】

【請求項1】 水晶基板と、前記水晶基板上に形成された圧電薄膜と、前記圧電薄膜上に形成されたくし歯電極とを備え、前記圧電薄膜の膜厚をH、表面波の波長をλとしたときに、圧電薄膜の規格化膜厚H／λが0．05以上とされていることを特徴とする、表面波装置。

【請求項2】 前記水晶基板と、前記圧電薄膜との間に形成された短絡電極とをさらに備える、請求項1に記載の表面波装置。

【請求項3】 水晶基板と、前記水晶基板上に形成された圧電薄膜と、前記圧電薄膜に接するように形成されたくし歯電極とを備え、

前記水晶基板として、群遅延時間温度特性ＴＣＤがマイナスの値をもつカット角及び伝搬方向の水晶基板が用いられていることを特徴とする、表面波装置。

【請求項4】 前記くし歯電極が、前記圧電薄膜上に形成されている、請求項3に記載の表面波装置。

【請求項5】 前記水晶基板と、前記圧電薄膜との間に形成された短絡電極をさらに備える、請求項4に記載の表面波装置。

【請求項6】 前記圧電薄膜の膜厚をH、表面波の波長をλとしたときに、圧電薄膜の規格化された膜厚H／λが0．03以上である、請求項3～5のいずれかに記載の表面波装置。

【請求項7】 前記圧電薄膜が、ＺｎＯ、ＡｌＮ、Ta_2O_5 及びＣｄＳからなる群から選択した一種よりなる圧電薄膜である、請求項1～6のいずれかに記載の表面波装置。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は、水晶基板を用いた表面波装置に関し、特に、水晶基板上に圧電薄膜を積層してなる表面波基板を用いた表面波装置の改良に関する。

【０００２】

【従来の技術】従来より、例えば移動体通信機器の帯域フィルタなどに表面波装置が広く用いられている。表面波（以下、ＳＡＷ）装置は、圧電体と接するように少なくとも一対のくし歯電極よりなる少なくとも1つのインターデジタルトランスデューサ（以下、ＩＤＴ）を形成した構造を有する。

【０００３】また、近年、圧電薄膜を用いたＳＡＷ装置も種々提案されている。すなわち、ガラス基板や圧電基板上に圧電薄膜を形成してなる表面波基板を用いたＳＡＷ装置が提案されている。

【０００４】上記圧電薄膜と、ガラス基板とを用いた構成では、図1（ａ），（ｂ）及び図2（ａ），（ｂ）に示す4種類の構造が知られている。すなわち、図1（ａ）に示すＳＡＷ装置1では、ガラス基板2上に圧電薄膜としてＺｎＯ薄膜3が形成されており、ＺｎＯ薄膜3上にＩＤＴ4が形成されている。他方、図1（ｂ）に示すＳＡＷ装置5では、ＩＤＴ4が、ＺｎＯ薄膜3の下面に、すなわちガラス基板2とＺｎＯ薄膜3との間の界面に形成されている。

【０００５】また、図2（ａ）に示すＳＡＷ装置6では、ガラス基板2上に、短絡電極7が形成されており、該短絡電極7上にＺｎＯ薄膜3が積層されている。ＩＤＴ4は、このＺｎＯ薄膜3上に形成されている。すなわち、ＳＡＷ装置6は、図1（ａ）に示したＳＡＷ装置1において、ガラス基板2とＺｎＯ薄膜3との界面に短絡電極7を挿入した構造に相当する。

【０００６】図2（ｂ）に示すＳＡＷ装置8では、短絡電極7がＺｎＯ薄膜3上に形成されている。また、ＩＤＴ4がガラス基板2とＺｎＯ薄膜3との間の界面に形成されている。従って、ＳＡＷ装置8は、図1（ｂ）に示したＳＡＷ装置5において、ＺｎＯ薄膜3の上面に上記短絡電極7を形成した構造に相当する。

【０００７】上記ＳＡＷ装置1，5，6，8を、ＩＤＴ4の形成位置及び短絡電極7の有無のみを異ならせ、他の構成は同一とした場合の電気機械結合係数を図3に示す。図3では、上記4種類のＳＡＷ装置1，5，6，8におけるＺｎＯ薄膜の規格化された膜厚H／λに対する電気機械結合係数の変化が示されている。なお、本明細書において、ＨはＺｎＯ薄膜の厚みを、λは励振される表面波の波長を示す。また、実線ＡがＳＡＷ装置1の結果を、破線ＢがＳＡＷ装置5の結果を、一点鎖線ＣがＳＡＷ装置6の結果を、二点鎖線ＤがＳＡＷ装置8の結果を示す。

【０００８】図3から明らかなように、H／λを選択することにより、ＳＡＷ装置5，8において、ＳＡＷ装置1，6に比べて大きな電気機械結合係数の得られることがわかる。従って、従来、ガラス基板2上にＺｎＯ薄膜3を形成した構造では、ＩＤＴ4をガラス基板2とＺｎＯ薄膜3との間の界面に形成した方が大きな電気機械結合係数が得られるとされていた。なお、図3中のセザワ波と記してある波はレイリー波の高次モードの表面波である。

【０００９】また、Ｊｐｎ．Ｊ．Ａｐｐｌ．Ｐｈｙｓ．Ｖｏｌ．３２（１９９３）２３３３～２３３６頁には、$LiNbO_3$ 圧電単結晶基板上にＺｎＯ薄膜を構成してなる表面波基板を用いた場合のＩＤＴや短絡電極の位置による電気機械結合係数の変化が示されている。これを、図4（ａ），（ｂ）及び図5（ａ），（ｂ）を参照して説明する。

【００１０】図4（ａ）は、図1（ａ）に示したＳＡＷ装置1におけるガラス基板2を$LiNbO_3$ 圧電単結晶基板に置き換えた構造のＳＡＷ装置についてのＺｎＯ薄膜の相対的膜厚ｋｈ（ｋは2π／λ、ｈはＺｎＯ薄膜の膜厚）と電気機械結合係数K^2 との関係を示す。なお、実線＋は$LiNbO_3$ のプラス面上にＺｎＯ薄膜を形成

した場合を、破線－は、$LiNbO_3$ のマイナス面にZnO薄膜を形成した場合の特性である。同様に、図4（b）は、図1（b）に示したSAW装置5のガラス基板2を$LiNbO_3$ 圧電単結晶基板に置き換えた場合の電気機械結合係数K^2 を示す図であり、実線は$LiNbO_3$ のプラス面上にZnO薄膜を形成した場合、破線はマイナス面上にZnO薄膜を形成した場合の特性を示す。さらに、図5（a）は、図2（a）に示したSAW装置6のガラス基板2を、図5（b）は図2（b）に示したSAW装置8のガラス基板2を、それぞれ、$LiNbO_3$圧電単結晶基板に置き換えた場合の電気機械結合係数K^2 の変化を示す図である。

【0011】図4及び図5から明らかなように、$LiNbO_3$ 圧電単結晶基板上に圧電薄膜としてZnO薄膜を形成した構造においても、図4（b）及び図5（b）から明らかなように、IDTを圧電単結晶基板とZnO薄膜との間の界面に形成した方が、大きな電気機械結合係数K^2 を実現し得ることがわかる。

【0012】すなわち、従来、ガラス基板や圧電基板上にZnO薄膜を形成した表面波基板を用いる場合、大きな電気機械結合係数を得るにはIDTを圧電薄膜と基板との間に形成すべきと考えられていた。

【0013】他方、用途によっては、電気機械結合係数が大きいだけでなく、温度特性が良好である、すなわち温度変化による特性の変化が小さい表面波基板が求められており、温度特性が良好な基板材料としては水晶が知られている。しかしながら、水晶基板は電気機械結合係数が比較的小さいという問題があった。

【0014】前述したように、水晶基板は良好な温度特性を有する。例えば、回転Yカット水晶基板では、図10に示すように、オイラー角と、TCD及び伝搬損失との間に図示のような関係のあることが知られている。ここで、TCDとは、遅延時間の温度による変化率（単位はppm／℃）を示す。

【0015】なお、図10において、実線Aは、回転Yカット水晶基板上で漏洩弾性表面波を励振した場合のTCDを、実線Bは伝搬損失を、破線Cはレイリー表面波のTCDを示す。但し、レイリー波の伝搬損失はゼロである。

【0016】図10に示すTCD及び伝搬損失特性が知られているため、従来、図10に示すオイラー角が130度近辺の回転Yカット水晶基板が用いられていた。すなわち、TCDが0付近のカット角の水晶基板が用いられ、該水晶基板上にIDTを形成してなるSAW装置が、温度特性の良好なSAW装置として用いられていた。

【0017】しかしながら、上記のように構成された水晶基板を用いたSAW装置においても、やはり、電気機械結合係数が小さく、従って、例えばSAWフィルタを構成した場合には、低挿入損失あるいは広帯域のフィルタ特性を得ることが困難であった。

【0018】

【発明が解決しようとする課題】本発明の目的は、水晶基板及び圧電薄膜を積層してなる表面波基板を用いたSAW装置において、電気機械結合係数をさらに高め得る構造を備えたものを提供することにある。

【0019】また、本発明の他の目的は、温度特性が良好であり、かつ電気機械結合係数がより一層大きなSAW装置を提供することにある。

【0020】

【課題を解決するための手段】本発明は、上記課題を達成するためになされたものであり、本願の第1の発明の広い局面によれば、水晶基板と、前記水晶基板上に形成された圧電薄膜と、前記圧電薄膜上に形成されたくし歯電極とを備え、圧電薄膜の膜厚をH、表面波の波長をλとしたときに、圧電薄膜の規格化膜厚H／λが0．05以上とされていることを特徴とする、表面波装置が提供される。

【0021】本願の第1の発明にかかる表面波装置では、上記のように水晶基板上に圧電薄膜が形成されており、くし歯電極は該圧電薄膜上に形成されている。すなわち、従来、非圧電基板あるいは圧電基板と圧電薄膜とを積層してなる表面波基板を用いる場合、IDTやくし歯電極は基板と圧電薄膜との間に形成すべきであり、その方が電気機械結合係数を大きくし得ると考えられていた。しかしながら、本願発明者は、圧電基板である水晶基板の場合には、水晶基板上に圧電薄膜を形成し、圧電薄膜上にくし歯電極を形成した方が、電気機械結合係数を高め得ることを見出し、さらに、その場合の圧電薄膜を上記特定の厚みとすれば、より一層電気機械結合係数を高め得ることを見出し、本願の第1発明をなすに至った。

【0022】上記表面波装置おいては、好ましくは、水晶基板と圧電薄膜との間に形成された短絡電極がさらに備えられる。本願の第2の発明の広い局面によれば、水晶基板と、前記水晶基板上に形成された圧電薄膜と、前記圧電薄膜に接するように形成されたくし歯電極とを備え、前記水晶基板として、遅延時間温度特性TCDがマイナスの値をもつカット角及び伝搬方向の水晶基板が用いられていることを特徴とする、表面波装置が提供される。

【0023】第2の発明では、後述の実施形態の説明から明らかなように、水晶基板としては、遅延時間温度特性TCDがマイナスの値を持つカット角及び伝搬方向の水晶基板が用いられ、他方、圧電薄膜が水晶基板上に積層されている。圧電薄膜は、通常、遅延時間温度特性TCDがプラスの値を有する。従って、本発明の上記表面波装置では、遅延時間温度特性TCDが、水晶基板と圧電薄膜とにより相殺されるため、良好な温度特性が実現される。

【0024】他方、後述するように、遅延時間温度特性ＴＣＤがマイナスの値を持つカット角及び伝搬方向の水晶基板は、遅延時間温度特性ＴＣＤがゼロに近いカット角及び伝搬方向の水晶基板に比べて、大きな電気機械結合係数を有する。よって、第２の発明によれば、温度特性が良好であり、かつより大きな電気機械結合係数を有する表面波装置を提供することができる。

【0025】第２の発明の別の特定的な局面によれば、上記くし歯電極は、圧電薄膜上に形成され、従って第１の発明の場合と同様に、より一層大きな電気機械結合係数を実現することができる。

【0026】さらに、第２の発明の別の特定的な局面によれば、水晶基板と、圧電薄膜との間に形成された短絡電極がさらに備えられ、それによって電気機械結合係数が高められる。

【0027】また、第２の発明のさらに別の局面によれば、圧電薄膜の膜厚Ｈ、表面波の波長λとしたときに、圧電薄膜の規格化された膜厚Ｈ／λが０．０３以上とされ、それによって電気機械結合係数がより一層高められる。

【0028】また、本願の第１，第２発明では、上記圧電薄膜は、ＺｎＯ、ＡｌＮ、Ta_2O_5 及びＣｄＳからなる群から選択した一種により構成され得る。もっとも、他の圧電薄膜を用いてもよい。上述した材料からなる圧電薄膜は、遅延時間温度特性ＴＣＤはプラスの値を有する。従って、本願の第２の発明では、圧電薄膜を上記材料から構成することにより、前述したように温度特性が良好なＳＡＷ装置を構成することができる。

【0029】本願の第１，第２の発明にかかるＳＡＷ装置は、ＳＡＷフィルタ、ＳＡＷ共振子、ＳＡＷ遅延線など種々のＳＡＷデバイスに適用し得る。

【0030】

【発明の実施の形態】以下、図面を参照しつつ本発明の前提となる技術を参考例１，２として先ず説明する。

【0031】参考例１

まず、７６．２mm径×０．５mmの寸法を有するＳＴカットＸ方向伝搬水晶基板を用いて、下記の３種類のＳＡＷ装置を作製した。

【0032】ＳＡＷ装置１１…上記水晶基板上にＺｎＯ薄膜を全面に形成し、その上に所定距離を隔てて２個のＩＤＴを形成し、ＳＡＷフィルタを作製した。すなわち、図９（ａ）に示すように、圧電薄膜１２上において、所定距離を隔ててＩＤＴ１３，１４を形成した。ＩＤＴ１３，１４は、それぞれ、一対のくし歯電極１３ａ，１３ｂ及び１４ａ，１４ｂを有する。また、このＳＡＷ装置１１では、図９（ｂ）に示すように、上記水晶基板１０上にＺｎＯ薄膜１２が形成されている。

【0033】ＳＡＷ装置１２…ＳＡＷ装置１１とは異なり、水晶基板とＺｎＯ薄膜との間にＩＤＴを形成したことを除いては、ＳＡＷ装置１と同様にしてＳＡＷ装置２を形成した。

【0034】ＳＡＷ装置１３…ＳＡＷ装置１１において、ＺｎＯ薄膜と水晶基板との間に界面の全面にＡｌよりなる短絡電極を形成し、その他はＳＡＷ装置１１と同様とした。

【0035】上記ＳＡＷ装置１１～１３において、ＺｎＯ薄膜の厚みを種々変更し、ＺｎＯ薄膜の厚みと電気機械結合係数との関係を測定した。結果を図６に示す。図６において、破線Ｄ、実線Ｅ及び一点鎖線Ｆが、それぞれ、ＳＡＷ装置１１，１２，１３の結果を示す。なお、図６の横軸は、ＺｎＯ薄膜の規格化された膜厚Ｈ／λを示す。

【0036】図６から明らかなように、ＺｎＯ薄膜の膜厚を調整することにより、ＳＡＷ装置１３において最も大きな電気機械結合係数が得られ、次に、ＳＡＷ装置１１において大きな電気機械結合係数が得られ、ＳＡＷ装置１２ではＺｎＯ薄膜を形成することにより逆に電気機械結合係数が小さくなることがわかる。すなわち、図６に示す結果は、ＳＴカットＸ方向伝搬水晶基板では、ＺｎＯの形成されていない水晶に比べ、ＩＤＴをＺｎＯ膜と水晶の間に形成すると電気機械結合係数が小さくなり、一方ＩＤＴをＺｎＯ薄膜の上に形成した場合に、大きな電気機械結合係数の得られることを示し、より好ましくは、短絡電極をさらに水晶基板とＺｎＯ薄膜との間の界面に挿入することにより、より大きな電気機械結合係数の得られることを示している。

【0037】参考例２

７６．２mm径×０．５mmの寸法の１６５°回転Ｙ板Ｘ方向伝搬（オイラー角では０°，７５°，０°）の水晶基板を用い、下記のＳＡＷ装置１４～１６を作製した。

【0038】ＳＡＷ装置１４…基板材料を上記回転Ｙ板Ｘ方向伝搬水晶基板としたしことを除いては前述した参考例１のＳＡＷ装置１１と同様に構成した。

ＳＡＷ装置１５…水晶基板として、上記回転Ｙ板Ｘ方向伝搬水晶基板を用いたことを除いては参考例１で作製したＳＡＷ装置１２と同様に構成した。

【0039】ＳＡＷ装置１６…上記回転Ｙ板Ｘ方向伝搬水晶基板を用いたことを除いては、参考例１で作製したＳＡＷ装置１３と同様にしてＳＡＷ装置１６を構成した。

上記ＳＡＷ装置１４～１６において、ＺｎＯ薄膜の膜厚を種々異ならせ、電気機械結合係数を測定した。結果を図７に示す。

【0040】図７において、破線ＧはＳＡＷ装置１４の特性を、実線ＨはＳＡＷ装置１５の結果を、一点鎖線ＩはＳＡＷ装置１６の結果を示す。図７から明らかなように、回転Ｙ板Ｘ方向伝搬水晶基板を用いた場合においても、参考例１の場合と同様に、ＩＤＴ、すなわち、くし歯電極をＺｎＯ薄膜と水晶基板との間に形成するより

も、ZnO薄膜上に形成した場合の方が大きな電気機械結合係数の得られることがわかる。また、一点鎖線I及び破線Gの特性を比較すれば明らかなように、さらに水晶基板とZnO薄膜との間に短絡電極を形成することにより、より一層大きな電気機械結合係数の得られることがわかる。

【0041】上述した参考例1及び2の結果から、カット角が異なる水晶基板を用いた場合であっても、水晶基板上にZnO薄膜を形成してなる表面波基板を用いる場合には、くし歯電極をZnO薄膜上に形成することにより大きな電気機械結合係数の得られることがわかる。上記参考例1，2を前提として、さらに電気機械結合係数を高め得る、本発明の実験例につき説明する。

【0042】<u>実験例1</u>

先ず、76．2mm径×0．5mmの寸法を有する115°回転Y板からなる水晶基板を用いた。このカット角の水晶基板は、漏洩弾性表面波において最も大きな電気機械結合係数を得られることが知られている基板材料の一つである。また、漏洩弾性表面波の伝搬方向はX方向である。

【0043】上記115°回転Y板X方向伝搬水晶基板を用い、下記の漏洩弾性表面波を用いたSAW装置17～19を作製した。

SAW装置17…上記水晶基板を用いたことを除いては、SAW装置11と同様にして構成した。

【0044】SAW装置18…上記水晶基板を用いたことを除いては、SAW装置12と同様にしてSAW装置18を作製した。

SAW装置19…上記特定の水晶基板を用いたことを除いては、SAW装置13と同様にしてSAW装置19を作製した。

【0045】上記SAW装置17～19のZnO薄膜の厚みを種々異ならせ、その電気機械結合係数を測定した。結果を図8に示す。図8において、破線JはSAW装置17の結果を、実線KはSAW装置18についての結果を、一点鎖線LはSAW装置19についての実験結果を示す。

【0046】また、図8に示した特性において、励振された表面波が漏洩弾性表面波である場合と、通常のレイリー波である場合との区別を図8に示した。すなわち、図8から明らかなように、ZnO薄膜の規格化された膜厚がH／λ＝0．14未満（二点鎖線Mで示す位置）では、減衰を伴う漏洩弾性表面波が励振され、伝搬を用いるトランスバーサル型等のSAW装置には使用することができないことがわかった。但し、伝搬を必要としないSAW素子には使用できる可能性がある。従って、ZnO薄膜の規格化された膜厚を0．14以上とすることにより、減衰の伴わない電気機械結合係数の大きなSAW装置の得られることがわかる。

【0047】また、図8から明らかなように、水晶基板とZnO薄膜との間にくし歯電極を形成したSAW装置18では、漏洩弾性表面波を効果的に励振し得ないことがわかる。これに対して、IDT、すなわちくし歯電極をZnO薄膜上に形成してなるSAW装置17，19では、上記H／λを0．14以上とすることにより、電気機械結合係数が大きく、かつ減衰のない漏洩弾性表面波を利用したSAW装置を提供し得ることがわかる。漏洩弾性表面波の場合、図10Bに示したように、基板のカット角により減衰を示す伝搬定数が異なり、ここで示した115°回転Y板X伝搬では、0．2dB／λの減衰があるが、カット角によっては、減衰がゼロのところ（例えば、105°回転Y板や30°回転Y板のX伝搬）がある。このようなカット角では、ZnO膜厚H／λが0．05より大きいところで減衰が伴わず、大きい電気機械結合係数が得られる。

【0048】なお、図6～図8に示した結果を比較すれば明らかなように、使用する水晶基のカット角と使用する表面波を励振し得るZnO薄膜の規格化された膜厚H／λが異なることがわかり、前述したSTカットX方向伝搬水晶基板、及び165°回転Y板X方向伝搬水晶基板のようにレイリー波表面波の場合、H／λを0．05以上とすればよいことが、さらに漏洩弾性表面波の場合には、115°回転Y板X伝搬水晶基板ではH／λが0．14以上、105°回転Y板X伝搬水晶基板ではH／λが0．05以上とすればよい。従って、水晶基板上にZnO薄膜を形成する場合、ZnO薄膜の規格化された膜厚H／λは0．05以上とすることが望ましい。

【0049】上記のように、使用した水晶基板として、オイラー角の異なる回転Y板を種々用いたため、オイラー角が異なる水晶基板を用いた上記SAW装置を多数種類作成した。このようにして得たSAW装置の上記オイラー角と電気機械結合係数K^2との関係を図16（a）に○印を付して示す。

【0050】なお、図16（a）の実線Nは漏洩表面波の、破線Pはレイリー波の場合の回転Y板X伝搬の水晶基板自体の電気機械係合係数を示す。図中○印と●印は、それぞれ、水晶の上にZnO膜を形成し、さらにその上にIDTを形成した構造におけるレイリー波と漏洩弾性表面波の電気機械結合係数の自乗値K^2を示している。一方△印と▲印は、それぞれ、その構造にさらにZnOと水晶との境界に短絡電極を設けた場合のレイリー波と漏洩弾性表面波の電気機械結合係数の自乗値K^2を示している。このようにK^2は、カット角により、多少異なる。また、図16（b）は、図10と同じ図であるが、図16（a）との比較のために図16（a）の直下に再度図示しているものである。

【0051】<u>実験例2</u>

図10を参照して説明したように、従来、水晶基板を用いたSAW装置を構成する場合、温度特性を良くするためには、TCDがゼロの近辺のカット角を有する水晶基

板を用いていたが、この場合充分大きな電気機械結合係数を得ることができなかった。本願発明者は、図１０に示すオイラー角と、ＴＣＤとの関係において、ＴＣＤがマイナスである水晶基板と、ＺｎＯ薄膜とを組み合わせれば、良好なＴＣＤ及び大きな電気機械結合係数を得られることを見出した。

【００５２】なお、水晶基板のカット角及び伝搬方向と、ＴＣＤとの関係は、いずれの水晶基板においても、ＴＣＤがマイナスの領域は存在する。これを、図１１～図１４を参照して説明する。

【００５３】図１１は、ＳＴカット水晶基板における伝搬方向のＸ軸からの角度θとＴＣＤとの関係を示し、図１２はＸカット水晶基板の伝搬方向のＹ軸からの角度θとＴＣＤとの関係を、図１３はＹカット水晶基板の伝搬方向のＸ軸からの角度θとＴＣＤとの関係を、図１４はＺカット水晶基板の伝搬方向のＸ軸からの角度θとＴＣＤとの関係を示す。図１１～図１４から明らかなように、これらの水晶基板においても、伝搬方向角θを変更することにより、ＴＣＤがマイナスとなる領域が存在することがかわる。

【００５４】本願の第２の発明は、上記のようなＴＣＤがマイナスの値を示すカット角あるいは伝搬方向の水晶基板を、ＴＣＤがプラスの値を示す圧電薄膜とを組み合わせることにより、良好なＴＣＤと大きな電気機械結合係数とを実現するものである。これを、回転Ｙ板からなる水晶基板を例にとり、図１５を参照して説明する。

【００５５】まず、水晶基板として、７６．２mm径×０．５mmの寸法の基板を用意した。なお、この水晶基板としては、１６５°回転Ｙ板Ｘ伝搬とＳＴカット３５°伝搬の２種類を用意した。

【００５６】上記水晶基板上にＺｎＯ膜をＨ／λ＝０～０．５までの膜厚で成膜し、さらにその上に上記伝搬方向に一致するようにＩＤＴを形成した。そのＳＡＷは特性の遅延時間の温度特性（温度１５，２５，３５℃の３点）を測定した。その結果を図１５に示す。１６５°回転Ｙ板Ｘ伝搬では、Ｈ／λ＝０．３５近傍で、ＳＴカット３５°伝搬ではＺｎＯ膜厚Ｈ／λ＝０．１６近傍でＴＣＤ＝０になるのがわかる。また、この膜厚での電気機械結合係数は前述のように大きい値を示す。すなわち、１６５°回転Ｙ板Ｘ伝搬の場合には、従来、電気機械結合係数K^2が０．２％、ＴＣＤ＝－３０ｐｐｍ／℃であったものが、水晶基板にＨ／λ＝０．３５のＺｎＯ膜とＩＤＴを形成することにより、従来の５倍のK^2＝１．０４％とＴＣＤ＝０ｐｐｍ／℃が得られた。また、ＺｎＯ膜と水晶基板との間に短絡電極を設けることにより、ＴＣＤ＝０ｐｐｍ／℃となり、K^2はさらに大きい１．３５％が得られる。

【００５７】一方、ＳＴカット３５°伝搬の場合にも、従来、K^2＝０．１４％、ＴＣＤ＝－２０ｐｐｍ／℃であったのが、水晶基板上にＨ／λ＝０．１６のＺｎＯ膜とＩＤＴを形成することにより、K^2は４．８倍のK^2＝０．７７％とＴＣＤ＝０ｐｐｍ／℃が得られる。また、ＺｎＯ膜と水晶基板との間に短絡電極を設けると、さらにK^2＝０．８９％とＴＣＤ＝０ｐｐｍ／℃が得られる。

【００５８】従って、本実験例から明らかなように、水晶基板として、電気機械結合係数が大きなオイラー角の水晶基板を用い、その場合にＴＣＤがマイナスの値を有していたとしても、ＺｎＯ薄膜として水晶基板のＴＣＤのマイナスの値を相殺し得るプラスのＴＣＤを示すＺｎＯ薄膜を形成し、その上にＩＤＴを形成することにより、非常に大きな電気機械結合係数及び良好な温度特性を有するＳＡＷ装置を構成し得ることがわかる。

【００５９】上記説明は、２種類の基板について説明したが、回転Ｙ板や、図１１～図１４に示した他のカット角の水晶基板を用いた場合においても、同様に、ＴＣＤがマイナスであっても、電気機械結合係数が大きなオイラー角の水晶基板を用いることにより、電気機械結合係数が大きくかつ温度特性が良好な表面波装置を構成し得ることがわかる。すなわち、図１０に示したように、回転Ｙ板Ｘ伝搬におけるレイリー波では、オイラー角（０，０，０）～（０，１３５，０）の範囲、漏洩表面波ではオイラー角（０，０，０）～（０，２０，０）、（０，４５，０）～（０，６５，０）、（０，１３５，０）～（０，１８０，０）の範囲がＴＣＤがマイナスの範囲である。図１１に示したように、ＳＴカット水晶基板を用いた場合には、オイラー角（０、１３２．７５±５、０）から（０、１３２．７５±５、５０）の間、及び（０、１３２．７５±５、１３０）から（０、１３２．７５±５、１８０）の間で、ＴＣＤがマイナスの範囲にある。

【００６０】また、図１２から明らかなように、回転Ｘカット水晶基板では、オイラー角が（９０、９０、０）～（９０、９０、３５）の範囲及び（９０、９０、１４５）～（９０，９０，１８０）の間でＴＣＤがマイナスとなっている。

【００６１】同様に、図１３に示されているように、回転Ｙカット水晶基板では、オイラー角が（０，９０、０）から（０，９０，３５）の間、及び（０，９０，１４５）～（０，９０，１８０）の間でＴＣＤがマイナスとなっている。また、図１４から明らかなように、Ｚカット水晶基板では、オイラー角（０，０，φ）のφが０、６０、１２０及び１８０以外の伝搬方向の場合にＴＣＤの値がマイナスの値となっている。

【００６２】従って、上述した範囲で各水晶基板では、ＴＣＤがマイナスの値を示すが、その範囲の中でも電気機械結合係数の大きいカット角を選択し、ＴＣＤのマイナスの値を相殺するように、プラスのＴＣＤ値を有するＺｎＯ薄膜を各水晶基板の上面に形成し、さらにＩＤＴを形成することにより、上記と同様に電気機械結合係数

が大きくかつ温度特性が良好な表面波装置を構成することができる。

【0063】また、水晶基板のような単結晶の材料を用いた場合には、そのカット角の異方性により、ＩＤＴからＩＤＴに向かう位相速度ベクトルの方向と実際のエネルギーの伝搬方向が一致しなくなることがあり、この現象をパワーフローといい、このとき生じる角度をパワーフロー角という。このパワーフローを考慮した場合、パワーフロー角が０であり、同時に、ＴＣＤがマイナスの値を示すような角が０であるような水晶基板のカット角が好ましい。この好ましいカット角は、オイラー角（０，２５，０）～（０，１０５，０）の間、（０，０，１５）～（０，４５，３５）の間、（０，１０，６０）～（０，２０，７０）の間、（０，９０，３０）～（０，１８０，４５）の間、（０，０，８５）～（０，０，９０）の間、（９０，９０，２５）～（９０，９０，３１）の間、（０，９０，－３）～（０，９０，３）の間であり、この場合ＴＣＤがマイナスでありかつパワーフロー角が０である。

【0064】従って、上述した範囲で各水晶基板上にＺｎＯ薄膜を形成し、さらにＩＤＴを形成することにより、電気機械結合係数が大きくかつ温度特性が良好で伝搬方向に偏りのない表面波装置を構成することができる。

【0065】なお、上記実験例では圧電薄膜としてＺｎＯ薄膜を形成した場合を説明したが、ＺｎＯ薄膜のほか、ＡｌＮ、Ta_2O_5、ＣｄＳなどのプラスのＴＣＤ値を有する適宜の圧電薄膜を用いてもよい。

【0066】さらに、水晶基板については、プラス面及びマイナス面の何れを用いてもよいことを指摘しておく。

【0067】

【発明の効果】以上のように、本願の第１の発明では、水晶基板上に形成された圧電薄膜上にくし歯電極が形成されており、圧電薄膜の規格化膜厚H／λを０．０５以上としているため、大きな電気機械結合係数の得られる表面波装置を提供することができる。すなわち、従来、大きな電気機械結合係数を得られるとされていた水晶基板と圧電薄膜との間にくし歯電極を形成した構造に比べて、電気機械結合係数を飛躍的に高めることが可能となる。

【0068】また、本願の第２の発明によれば、水晶基板としてＴＣＤがマイナスの値をもつカット角及び伝搬方向の水晶基板が用いられ、該水晶基板上に圧電薄膜が形成されている。従って、圧電薄膜が通常プラスのＴＣＤ値を有するため、水晶基板のＴＣＤ値が圧電薄膜のＴＣＤ値により相殺され、温度特性の良好な表面波装置を得ることができる。よって、ＴＣＤ値がマイナスであっても、電気機械結合係数の大きいカット角及び伝搬方向の水晶基板を用いることにより、従来実現することができなかった、温度特性が良好であり、しかも大きな電気機械結合係数を有する表面波装置を提供することが可能となる。

【図面の簡単な説明】

【図１】（ａ）及び（ｂ）は、それぞれ、従来の表面波装置におけるガラス基板、圧電薄膜及びＩＤＴの積層構造を示す各断面図。

【図２】（ａ）及び（ｂ）は、それぞれ、従来のＳＡＷ装置におけるガラス基板、短絡電極、圧電薄膜及びＩＤＴの積層構造を説明するための各断面図。

【図３】図１及び図２に示したＳＡＷ装置における圧電薄膜の規格化された膜厚と、電気機械結合係数との関係を示す図。

【図４】（ａ）及び（ｂ）は、それぞれ、従来のＳＡＷ装置において、$LiNbO_3$基板上に圧電薄膜及びＩＤＴを形成した構造及び$LiNbO_3$基板上にＩＤＴ及び圧電薄膜をこの順に積層した構造における、ＺｎＯ薄膜の規格化された膜厚と電気機械結合係数との関係を示す図。

【図５】（ａ）及び（ｂ）は、それぞれ、$LiNbO_3$基板上にＺｎＯ薄膜を形成してなる表面波基板においてＩＤＴ及び短絡電極を異なる位置に形成した場合のＺｎＯ薄膜の規格化された膜厚と電気機械結合係数との関係を示す図。

【図６】ＳＴカット水晶基板上に圧電薄膜とくし歯電極とを形成した３種類の表面波装置のＺｎＯ薄膜の規格化された膜厚と電気機械結合係数との関係を示す図。

【図７】１６５°回転Ｙ板Ｘ方向伝搬水晶基板上にＺｎＯ薄膜及びくし歯電極を形成した３種類の構造の表面波装置のＺｎＯ薄膜の規格化された膜厚と電気機械結合係数との関係を示す図。

【図８】１１５°回転Ｙ板からなる水晶基板上にＺｎＯ薄膜及びくし歯電極を種々の形態に構成した表面波装置におけるＺｎＯ薄膜の規格化された膜厚と電気機械結合係数との関係を示す図。

【図９】（ａ）及び（ｂ）は、参考例及び本発明の一実施形態として構成されるＳＡＷ装置の模式的平面図及びくし歯電極が形成されている部分の部分切欠断面図。

【図１０】回転Ｙ板水晶基板におけるオイラー角とＴＣＤ及び伝搬損失との関係を示す図。

【図１１】ＳＴカット水晶基板における伝搬方向とＴＣＤとの関係を示す図。

【図１２】Ｘカット水晶基板の伝搬方向とＴＣＤとの関係を示す図。

【図１３】Ｙカット水晶基板の伝搬方向とＴＣＤとの関係を示す図。

【図１４】Ｚカット水晶基板の伝搬方向とＴＣＤとの関係を示す図。

【図１５】１６５°回転Ｙ板Ｘ伝搬とＳＴカット３５°伝搬水晶基板を用いた場合のＺｎＯ膜厚とＴＣＤとの関

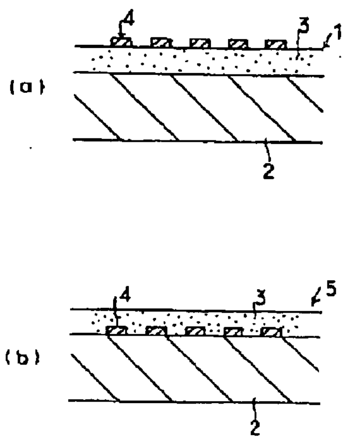
係を示す図。

【図１６】（ａ）及び（ｂ）は、それぞれ、本願の第２の発明の実施形態における回転Ｙ板水晶基板のオイラー角と電気機械結合係数との関係を示す図、並びにオイラー角とＴＣＤ及び伝搬損失との関係を示す図。

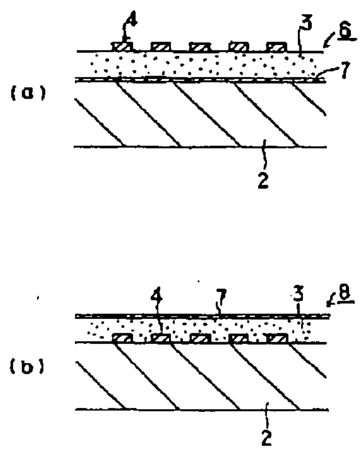
【符号の説明】

１０…水晶基板
１１…ＳＡＷ装置
１２…ＺｎＯ薄膜
１３，１４…ＩＤＴ
１３ａ，１３ｂ，１４ａ，１４ｂ…くし歯電極

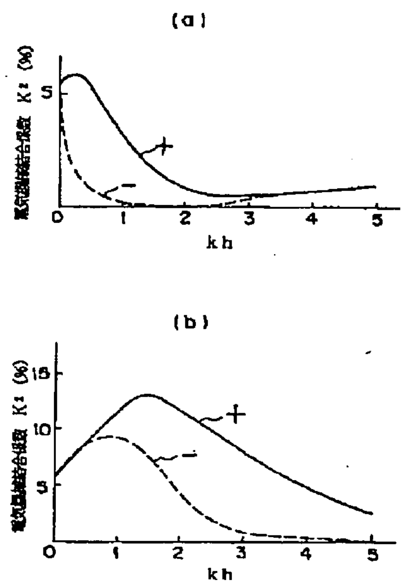
【図１】



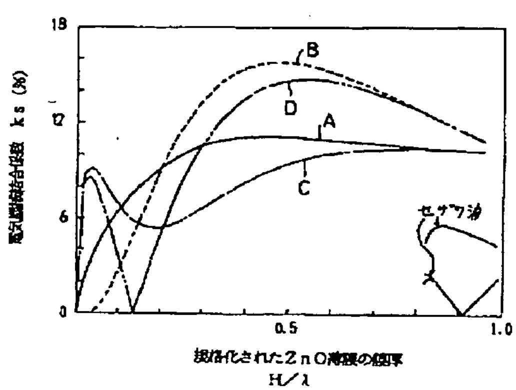
【図２】



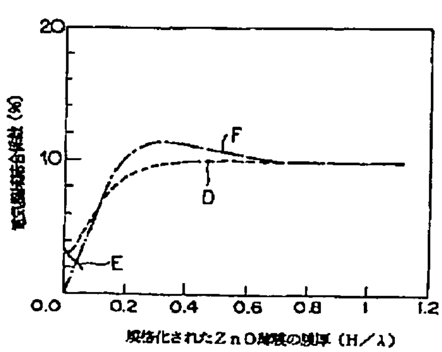
【図４】



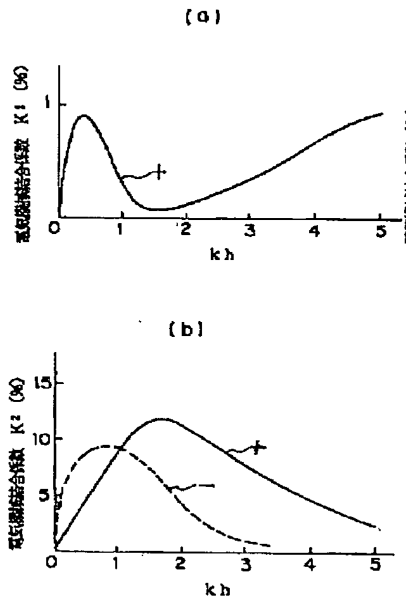
【図３】



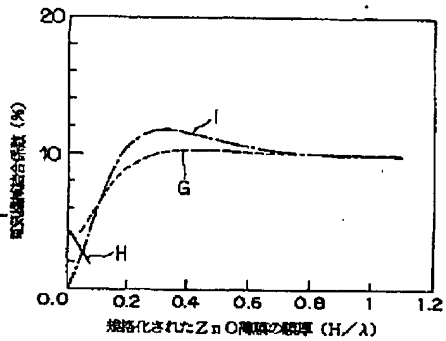
【図６】



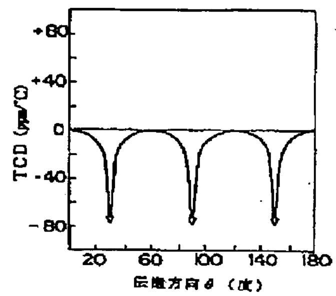
【図5】



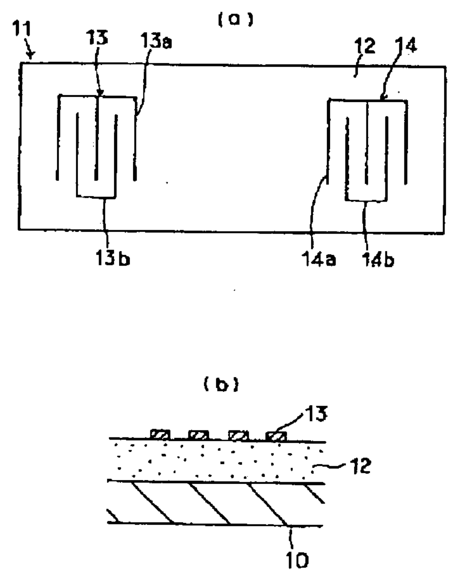
【図7】



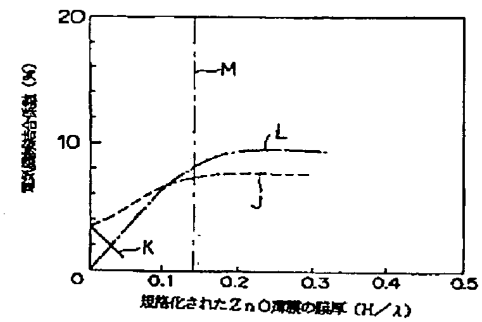
【図14】



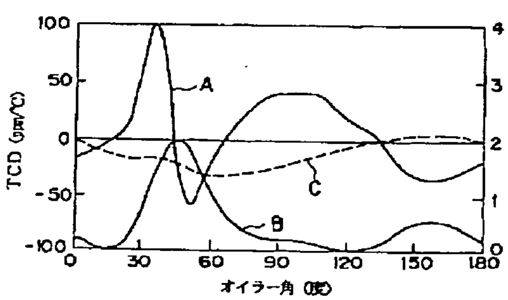
【図9】



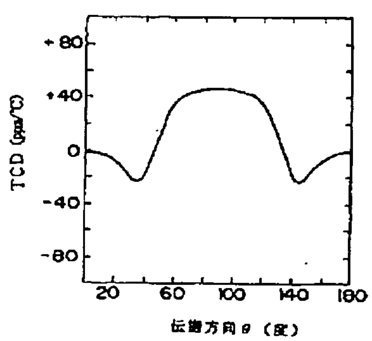
【図8】



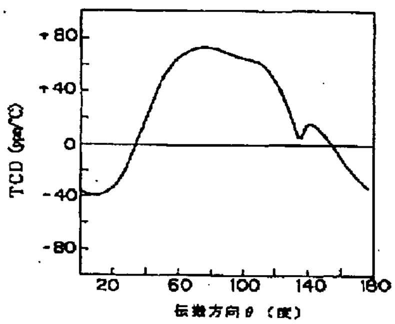
【図10】



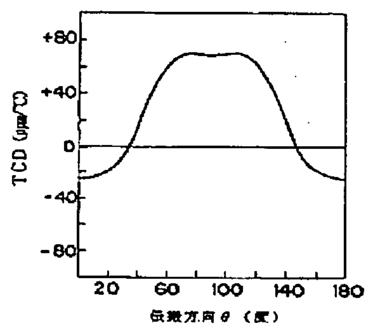
【図11】



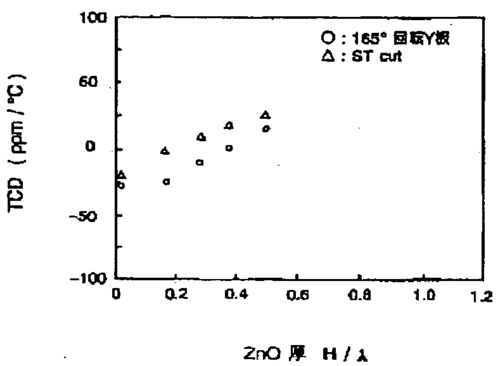
【図12】



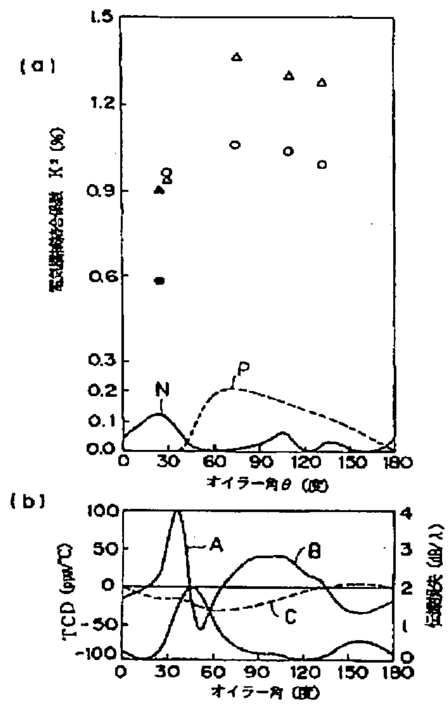
【図13】



【図15】



【図16】



Bibliography

---

(19) [Publication country] Japan Patent Office (JP)
(12) [Kind of official gazette] Open patent official report (A)
(11) [Publication No.] JP, 9-130192, A
(43) [Date of Publication] May 16, Heisei 9 (1997)
(54) [Title of the Invention] Surface wave equipment
(51) [International Patent Classification (6th Edition)]
H03H 9/145
[FI]
H03H 9/145 C 7259-5J
[Request for Examination] Un-asking.
[The number of claims] 7
[Mode of Application] OL
[Number of Pages] 10
(21) [Application number] Japanese Patent Application No. 8-228781
(22) [Filing date] August 29, Heisei 8 (1996)
(31) [Application number of the priority] Japanese Patent Application No. 7-225270
(32) [Priority date] Taira 7 (1995) September 1
(33) [Country Declaring Priority] Japan (JP)
(71) [Applicant]
[Identification Number] 000006231
[Name] Murata Manufacturing Co., Ltd.
[Address] 2-26-10, Tenjin, Nagaokakyo-shi, Kyoto
(72) [Inventor(s)]
[Name] Kadota Michio
[Address] 2-26-10, Tenjin, Nagaokakyo-shi, Kyoto Inside of Murata Manufacturing Co., Ltd.
(74) [Attorney]
[Patent Attorney]
[Name] Miyazaki The main tax (besides one person)

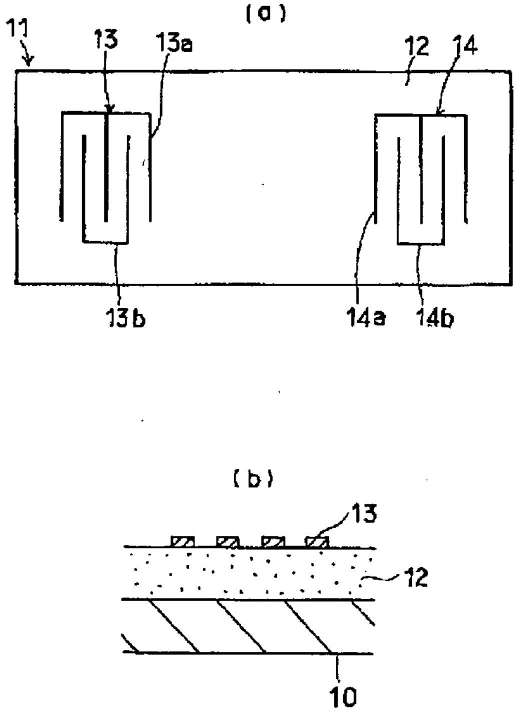
[Translation done.]

Epitome

(57) [Abstract]
[Technical problem] an electromechanical coupling coefficient is larger than before using the Xtal substrate -- SAW equipment offer is made.
[Means for Solution] SAW equipment which formed the ZnO thin film 12 on the Xtal substrate 10, came to form the sinking comb electrodes 13a, 13b, 14a, and 14b on the ZnO thin film 12, and made standardization thickness H/lambda of the ZnO thin film 12 0.05 or more.

[Translation done.]

(a)



(b)

[Translation done.]

* NOTICES *

JPO and NCIPI are not responsible for any
damages caused by the use of this translation.

1. This document has been translated by computer. So the translation may not reflect the original precisely.
2. **** shows the word which can not be translated.
3. In the drawings, any words are not translated.

CLAIMS

[Claim(s)]

[Claim 1] Surface wave equipment characterized by making standardization thickness H/lambda of a piezo-electric thin film or more into 0.05 when it forms on the Xtal substrate, the piezo-electric thin film formed on said Xtal substrate, and said piezo-electric thin film, and it carried out, and it has a gear-tooth electrode and wavelength of H and a surface

wave is set to lambda for the thickness of said piezo-electric thin film.
[Claim 2] Surface wave equipment according to claim 1 further equipped with said Xtal substrate and the short circuit electrode formed between said piezo-electric thin films.
[Claim 3] Surface wave equipment which forms and carries out, is equipped with a gear-tooth electrode so that the Xtal substrate, the piezo-electric thin film formed on said Xtal substrate, and said piezo-electric thin film may be touched, and is characterized by using the Xtal substrate of the cut angle in which the group delay temperature characteristic TCD has the value of minus as said Xtal substrate, and the propagation direction.
[Claim 4] Surface wave equipment according to claim 3 with which said sinking comb electrode is formed on said piezo-electric thin film.
[Claim 5] Surface wave equipment according to claim 4 further equipped with the short circuit electrode formed between said Xtal substrate and said piezo-electric thin film.
[Claim 6] Surface wave equipment according to claim 3 to 5 whose thickness H/lambda by which the piezo-electric thin film was standardized is 0.03 or more when wavelength of H and a surface wave is set to lambda for the thickness of said piezo-electric thin film.
[Claim 7] Said piezo-electric thin film is ZnO, AlN, and Ta 205. And surface wave equipment according to claim 1 to 6 which is the piezo-electric thin film which consists of a kind chosen from the group which consists of CdS.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]

[Field of the Invention] This invention relates to amelioration of the surface wave equipment using the surface wave substrate which comes to carry out the laminating of the piezo-electric thin film on the Xtal substrate especially about the surface wave equipment which used the Xtal substrate.

[0002]

[Description of the Prior Art] Conventionally, surface wave equipment is widely used for the band-pass filter of for example, mobile communication equipment etc. Surface wave (following, SAW) equipment has the structure in which at least one INTADEJITARUTORANSUDEYUSA (following, IDT) which consists of sinking comb electrodes of a pair at least so that a piezo electric crystal may be touched was formed.

[0003] Moreover, various SAW equipments using a piezo-electric thin film are also proposed in recent years. That is, the SAW equipment using the surface wave substrate which comes to form a piezo-electric thin film on a glass substrate or a piezo-electric substrate is proposed.

[0004] Four kinds of structures shown in drawing 1 (a), (b), and drawing 2 (a) and (b) are known for the configuration using the above-mentioned piezo-electric thin film and a glass substrate. That is, with the SAW equipment 1 shown in drawing 1 (a), the ZnO thin film 3 is formed as a piezo-electric thin film on the glass substrate 2, and IDT4 is formed on the ZnO thin film 3. On the other hand, IDT4 is formed in the inferior surface of tongue of the ZnO thin film 3, i.e., the interface between a glass substrate 2 and the ZnO thin film 3, with the SAW equipment 5 shown in drawing 1 (b).

[0005] Moreover, with the SAW equipment 6 shown in drawing 2 (a), the short circuit electrode 7 is formed on the glass substrate 2, and the laminating of the ZnO thin film 3 is carried out on this short circuit electrode 7. IDT4 is formed on this ZnO thin film 3. That is, SAW equipment 6 is equivalent to the structure which inserted the short circuit electrode 7 in the interface of a glass substrate 2 and the ZnO thin film 3 in the SAW equipment 1 shown in drawing 1 (a).

[0006] With the SAW equipment 8 shown in drawing 2 (b), the short circuit electrode 7 is formed on the ZnO thin film 3. Moreover, IDT4 is formed in the interface between a glass substrate 2 and the ZnO thin film 3. Therefore, SAW equipment 8 is equivalent to the structure in which the above-mentioned short circuit electrode 7 was formed on the top face of the ZnO thin film 3, in the SAW equipment 5 shown in drawing 1 (b).

[0007] The electromechanical coupling coefficient at the time of changing the above-mentioned SAW equipments 1, 5, 6, and 8, and making

only the formation location of IDT4 and existence of the short circuit electrode 7 the same [other configurations] for them is shown in drawing 3 . Change of the electromechanical coupling coefficient to thickness H/lambda by which the ZnO thin film in the four above-mentioned kinds of SAW equipments 1, 5, 6, and 8 was standardized is shown by drawing 3 . In addition, in this specification, H shows the wavelength of the surface wave by which lambda is excited in the thickness of a ZnO thin film. Moreover, as a result of a continuous line's A being SAW equipment 1, an alternate long and short dash line C shows the result of SAW equipment 6, and a two-dot chain line D shows [a broken line B] the result of SAW equipment 8 for the result of SAW equipment 5.

[0008] By choosing H/lambda shows that a big electromechanical coupling coefficient is obtained compared with the SAW equipments 1 and 6 in the SAW equipments 5 and 8 so that clearly from drawing 3 . Therefore, with the structure in which the ZnO thin film 3 was formed on the glass substrate 2, it was supposed conventionally that an electromechanical coupling coefficient with bigger forming IDT4 in the interface between a glass substrate 2 and the ZnO thin film 3 will be obtained. In addition, the wave currently described as the SEZAWA wave in drawing 3 is a surface wave of the higher mode of a Rayleigh wave.

[0009] Moreover, in Jpn. J. Appl. Phys. Vol. 32 (1993) 2333-2336 page, it is LiNbO3. Change of the electromechanical coupling coefficient by IDT at the time of using the surface wave substrate which comes to constitute a ZnO thin film on a piezo-electric single crystal substrate, or the location of a short circuit electrode is shown. This is explained with reference to drawing 4 (a), (b), and drawing 5 (a) and (b).

[0010] Drawing 4 (a) is LiNbO3 about the glass substrate 2 in the SAW equipment 1 shown in drawing 1 (a). The relative thickness kh (k is 2 pi/lambda and h is the thickness of a ZnO thin film) and the electromechanical coupling coefficient K2 of the ZnO thin film about the SAW equipment of structure replaced with a piezo-electric single crystal substrate Relation is shown. In addition, continuous-line + is LiNbO3. About the case where a ZnO thin film is formed on a plus side, broken-line - is LiNbO3. It is a property at the time of forming a ZnO thin film in a minus side. Similarly, drawing 4 (b) is LiNbO3 about the glass substrate 2 of the SAW equipment 5 shown in drawing 1 (b). Electromechanical coupling coefficient K2 at the time of transposing to a piezo-electric single crystal substrate It is shown drawing and a continuous line is LiNbO3. When a ZnO thin film is formed on a plus side, a broken line shows the property at the time of forming a ZnO thin film

on a minus side. Furthermore, drawing 5 (a) is the electromechanical coupling coefficient K2 at the time of transposing the glass substrate 2 of the SAW equipment 8 with which drawing 5 (b) showed the glass substrate 2 of the SAW equipment 6 shown in drawing 2 (a) to drawing 2 (b) to a LiNbO3 piezo-electricity single crystal substrate, respectively. It is drawing showing change.

[0011] It is LiNbO3 so that clearly from drawing 4 and drawing 5 . Electromechanical coupling coefficient K2 with bigger forming IDT in the interface between a piezo-electric single crystal substrate and a ZnO thin film also in the structure which formed the ZnO thin film as a piezo-electric thin film on the piezo-electric single crystal substrate, so that clearly from drawing 4 (b) and drawing 5 (b) It turns out that it can realize.

[0012] that is, when using conventionally the surface wave substrate in which the ZnO thin film was formed on the glass substrate or the piezo-electric substrate, for obtaining a big electromechanical coupling coefficient, IDT should be formed between a piezo-electric thin film and a substrate -- ** -- it thought.

[0013] On the other hand, an electromechanical coupling coefficient is not only large, but depending on the application, the temperature characteristic is good, namely, the surface wave substrate with a small change of the property by the temperature change is called for, and Xtal is known as a substrate ingredient with the good temperature characteristic. However, the Xtal substrate had the problem that an electromechanical coupling coefficient was comparatively small.

[0014] As mentioned above, the Xtal substrate has the good temperature characteristic. For example, as shown in drawing 10 , it is known for the rotation Y cut Xtal substrate that there is relation like illustration between an Eulerian angle, and TCD and a propagation loss. Here, TCD shows the rate of change (a unit is ppm/**) by the temperature of a time delay.

[0015] In addition, in drawing 10 , in a continuous line A, a continuous line B shows a propagation loss and a broken line C shows TCD of the Rayleigh surface wave for TCD at the time of exciting a leakage surface acoustic wave on a rotation Y cut Xtal substrate. However, the propagation loss of a Rayleigh wave is zero.

[0016] Since TCD and the propagation-loss property which are shown in drawing 10 were known, the rotation Y cut Xtal substrate of nearly 130 degrees was conventionally used for the Eulerian angle shown in drawing 10 . That is, the SAW equipment with which the Xtal substrate of the cut angle of the zero neighborhood is used, and TCD comes to form IDT on

this Xtal substrate was used as good SAW equipment of the temperature characteristic.

[0017] However, also in the SAW equipment using the Xtal substrate constituted as mentioned above, too, when an SAW filter was constituted, it was difficult [it / the electromechanical coupling coefficient was small, therefore] to obtain the filter shape of a low insertion loss or a broadband.

[0018]

[Problem(s) to be Solved by the Invention] The purpose of this invention is in the SAW equipment using the surface wave substrate which comes to carry out the laminating of the Xtal substrate and the piezo-electric thin film to offer the thing equipped with the structure which can raise an electromechanical coupling coefficient further.

[0019] Moreover, other purposes of this invention are to offer SAW equipment with a much more big electromechanical coupling coefficient good [the temperature characteristic].

[0020]

[Means for Solving the Problem] This invention is made in order to attain the above-mentioned technical problem, and according to the large aspect of affairs of invention of the 1st of this application When it forms on the Xtal substrate, the piezo-electric thin film formed on said Xtal substrate, and said piezo-electric thin film, and it carried out, and it has a gear-tooth electrode and wavelength of H and a surface wave is set to lambda for the thickness of a piezo-electric thin film, the surface wave equipment characterized by making standardization thickness H/lambda of a piezo-electric thin film or more into 0.05 is offered.

[0021] With the surface wave equipment concerning invention of the 1st of this application, the piezo-electric thin film is formed on the Xtal substrate as mentioned above, and the sinking comb electrode is formed on this piezo-electric thin film. That is, when the surface wave substrate which comes to carry out the laminating of a non-piezo-electricity substrate or a piezo-electric substrate, and the piezo-electric thin film was used conventionally, it burned IDT, and the gear-tooth electrode should be formed between the substrate and the piezo-electric thin film, and the direction of it was considered that it can enlarge an electromechanical coupling coefficient. However, it came [the invention-in-this-application person came in the header and the pan that the direction which formed the piezo-electric thin film on the Xtal substrate, and formed the sinking comb electrode on the piezo-electric thin film could raise an electromechanical coupling coefficient in the case of the Xtal substrate which is a piezo-electric substrate,

and] to make [the above-mentioned specific thickness, then that an electromechanical coupling coefficient can be raised further] the piezo-electric thin film in that case for the 1st invention of a header and this application.

[0022] the above-mentioned surface wave equipment -- if it is, it has further preferably the short circuit electrode formed between the Xtal substrate and the piezo-electric thin film. According to the large aspect of affairs of invention of the 2nd of this application, it forms and carries out and has a gear-tooth electrode so that the Xtal substrate, the piezo-electric thin film formed on said Xtal substrate, and said piezo-electric thin film may be touched, and the surface wave equipment characterized by using the Xtal substrate of the cut angle in which the time delay temperature characteristic TCD has the value of minus as said Xtal substrate, and the propagation direction is offered.

[0023] In the 2nd invention, the Xtal substrate of the cut angle in which the time delay temperature characteristic TCD has the value of minus as a Xtal substrate, and the propagation direction is used, and the laminating of another side and the piezo-electric thin film is carried out on the Xtal substrate so that clearly from explanation of the below-mentioned operation gestalt. As for a piezo-electric thin film, the time delay temperature characteristic TCD usually has the value of plus. Therefore, with the above-mentioned surface wave equipment of this invention, since the time delay temperature characteristic TCD is offset with the Xtal substrate and a piezo-electric thin film, the good temperature characteristic is realized.

[0024] On the other hand, the Xtal substrate of the cut angle in which the time delay temperature characteristic TCD has the value of minus, and the propagation direction has a big electromechanical coupling coefficient compared with the Xtal substrate of a cut angle with the time delay temperature characteristic TCD near zero, and the propagation direction so that it may mention later. Therefore, according to the 2nd invention, the temperature characteristic can offer the surface wave equipment which has a bigger electromechanical coupling coefficient good.

[0025] According to another specific aspect of affairs of the 2nd invention, the above-mentioned sinking comb electrode is formed on a piezo-electric thin film, therefore can realize a much more big electromechanical coupling coefficient like the case of the 1st invention.

[0026] Furthermore, according to another specific aspect of affairs of the 2nd invention, it has further the short circuit electrode formed between the Xtal substrate and the piezo-electric thin film, and an

electromechanical coupling coefficient is raised by it.
[0027] Moreover, according to still more nearly another aspect of affairs of the 2nd invention, when it considers as the thickness H of a piezo-electric thin film, and the wavelength lambda of a surface wave, thickness H/lambda by which the piezo-electric thin film was standardized is made or more into 0.03, and an electromechanical coupling coefficient is further raised by it.
[0028] Moreover, by the 1st and 2nd invention of this application, the above-mentioned piezo-electric thin film is ZnO, AlN, and Ta 2O5. And it may be constituted by kind chosen from the group which consists of CdS. But other piezo-electric thin films may be used. In the piezo-electric thin film which consists of an ingredient mentioned above, the time delay temperature characteristic TCD has the value of plus. Therefore, by constituting a piezo-electric thin film from an above-mentioned ingredient, as mentioned above, the temperature characteristic can constitute good SAW equipment from invention of the 2nd of this application.
[0029] The SAW equipment concerning invention of the 1st and the 2nd of this application can be applied to various SAW devices, such as an SAW filter, a SAW resonator, and the SAW delay line.
[0030]
[Embodiment of the Invention] Hereafter, the technique which will be the requisite for this invention is first explained as examples 1 and 2 of reference, referring to a drawing.
[0031] the example 1 of reference -- three kinds of following SAW equipments were first produced using the direction propagation Xtal substrate of ST cut X which has a diameter xof 76.2mm0.5mm dimension.
[0032] SAW equipment 11 -- The ZnO thin film was formed on the above-mentioned Xtal substrate on the whole surface, on it, predetermined distance was separated, two IDT(s) were formed, and the SAW filter was produced. That is, as shown in drawing 9 (a), on the piezo-electric thin film 12, predetermined distance was separated and IDT 13 and 14 was formed. IDT 13 and 14 has the sinking comb electrodes 13a and 13b of a pair, and 14a and 14b, respectively. Moreover, with this SAW equipment 11, as shown in drawing 9 (b), the ZnO thin film 12 is formed on the above-mentioned Xtal substrate 10.
[0033] SAW equipment 12 -- It differed in SAW equipment 11, and if it removed having formed IDT between the Xtal substrate and the ZnO thin film, SAW equipment 2 as well as SAW equipment 1 was formed.
[0034] SAW equipment 13 -- In SAW equipment 11, the short circuit electrode which consists of aluminum all over an interface was formed

between the ZnO thin film and the Xtal substrate, and others presupposed that it is the same as that of SAW equipment 11.

[0035] In the above-mentioned SAW equipments 11-13, various thickness of a ZnO thin film was changed and the relation between the thickness of a ZnO thin film and an electromechanical coupling coefficient was measured. A result is shown in drawing 6 . In drawing 6 , a broken line D, a continuous line E, and an alternate long and short dash line F show the result of the SAW equipments 11, 12, and 13, respectively. In addition, the axis of abscissa of drawing 6 shows thickness H/lambda by which the ZnO thin film was standardized.

[0036] By adjusting the thickness of a ZnO thin film shows that the biggest electromechanical coupling coefficient is obtained in SAW equipment 13, next a big electromechanical coupling coefficient is obtained in SAW equipment 11, and an electromechanical coupling coefficient becomes small by forming a ZnO thin film with SAW equipment 12 at reverse so that clearly from drawing 6 . The result shown in drawing 6 namely, in the direction propagation Xtal substrate of ST cut X Compared with Xtal with which ZnO is not formed, if IDT is formed between the ZnO film and Xtal, an electromechanical coupling coefficient will become small. On the other hand, when IDT is formed on a ZnO thin film, by showing that a big electromechanical coupling coefficient is obtained and inserting a short circuit electrode in the interface between the Xtal substrate and a ZnO thin film further more preferably shows that a bigger electromechanical coupling coefficient is obtained.

[0037] The following SAW equipments 14-16 were produced using the Xtal substrate of the direction propagation of 165-degree rotation Y cut X of a diameter xof example of reference 276.2mm0.5mm dimension (an Eulerian angle 0 degree, 75 degrees, 0 degree).

[0038] SAW equipment 14 -- It constituted like the SAW equipment 11 of the example 1 of reference mentioned above if the substrate ingredient was used as the above-mentioned direction propagation Xtal substrate of rotation Y cut X and things were removed.

SAW equipment 15 -- If it removed having used the above-mentioned direction propagation Xtal substrate of rotation Y cut X as a Xtal substrate, it constituted like the SAW equipment 12 produced in the example 1 of reference.

[0039] SAW equipment 16 -- If it removed having used the above-mentioned direction propagation Xtal substrate of rotation Y cut X, SAW equipment 16 as well as the SAW equipment 13 produced in the example 1 of reference was constituted.

In the above-mentioned SAW equipments 14-16, various thickness of a ZnO

thin film was changed and the electromechanical coupling coefficient was measured. A result is shown in drawing 7 .
[0040] In drawing 7 , in a broken line G, a continuous line H shows the result of SAW equipment 15, and an alternate long and short dash line I shows the result of SAW equipment 16 for the property of SAW equipment 14. When the direction propagation Xtal substrate of rotation Y cut X is used so that clearly from drawing 7 , it turns out [of an electromechanical coupling coefficient with the big direction at the time of forming on a ZnO thin film] like the case of the example 1 of reference is acquired rather than forming IDT, i.e., a sinking comb electrode, between a ZnO thin film and the Xtal substrate. Moreover, if the property of an alternate long and short dash line I and a broken line G is compared, by forming a short circuit electrode between the Xtal substrate and a ZnO thin film further shows that a much more big electromechanical coupling coefficient is obtained so that clearly.
[0041] Even if it is the case where the Xtal substrate with which cut angles differ is used from the result of the examples 1 and 2 of reference mentioned above, in using the surface wave substrate which comes to form a ZnO thin film on the Xtal substrate, it turns out by forming a sinking comb electrode on a ZnO thin film that a big electromechanical coupling coefficient is obtained. It explains per [which can raise an electromechanical coupling coefficient further on the assumption that the above-mentioned examples 1 and 2 of reference] example of an experiment of this invention.
[0042] the example 1 of an experiment -- the Xtal substrate which consists of a 115-degree rotation Y cut which has a diameter xof 76.2mm0.5mm dimension first was used. The Xtal substrate of this cut angle is one of the substrate ingredients with which it is known that the biggest electromechanical coupling coefficient can be obtained in a leakage surface acoustic wave. Moreover, the propagation direction of a leakage surface acoustic wave is the direction of X.
[0043] The SAW equipments 17-19 using the following leakage surface acoustic wave were produced using the above-mentioned direction propagation Xtal substrate of 115-degree rotation Y cut X.
SAW equipment 17 -- If it removed having used the above-mentioned Xtal substrate, it constituted like SAW equipment 11.
[0044] SAW equipment 18 -- If it removed having used the above-mentioned Xtal substrate, SAW equipment 18 as well as SAW equipment 12 was produced.
SAW equipment 19 -- If it removed having used the above-mentioned specific Xtal substrate, SAW equipment 19 as well as SAW equipment 13

was produced.
[0045] Various thickness of the ZnO thin film of the above-mentioned SAW equipments 17-19 was changed, and the electromechanical coupling coefficient was measured. A result is shown in drawing 8 . In drawing 8 , as for a continuous line K, a broken line J shows [the result of SAW equipment 17] the experimental result about SAW equipment 19 for the result about SAW equipment 18, as for an alternate long and short dash line L.
[0046] Moreover, in the property shown in drawing 8 , distinction of the case where the excited surface wave is a leakage surface acoustic wave, and the case where it is the usual Rayleigh wave was shown in drawing 8 . That is, it turned out that the leakage surface acoustic wave accompanied by attenuation is excited, and the thickness by which the ZnO thin film was standardized cannot use it for SAW equipments, such as a transversal mold using propagation, less than [H/lambda =0.14] (location shown with a two-dot chain line M) so that clearly from drawing 8 . However, it may be able to be used for the SAW component which does not need propagation. Therefore, by making or more into 0.14 thickness by which the ZnO thin film was standardized shows that SAW equipment with the big electromechanical coupling coefficient by which attenuation is not accompanied is obtained.
[0047] Moreover, with the SAW equipment 18 in which the sinking comb electrode was formed between the Xtal substrate and the ZnO thin film, it turns out that a leakage surface acoustic wave cannot be excited effectively so that clearly from drawing 8 . On the other hand, with the SAW equipments 17 and 19 which come to form IDT, i.e., a sinking comb electrode, on a ZnO thin film, an electromechanical coupling coefficient is large and by making above-mentioned H/lambda or more into 0.14 shows that the SAW equipment using a leakage surface acoustic wave without attenuation can be offered. In the case of a leakage surface acoustic wave, as shown in drawing 10 B, there is attenuation of 0.2 dB/lambda by the 115-degree rotation Y cut X propagation which the propagation constants which show attenuation according to the cut angle of a substrate differed, and was shown here, but depending on a cut angle, there is a place (for example, X propagation of 105-degree rotation Y cut or 30-degree rotation Y cut) whose attenuation is zero. On such a cut square, attenuation does not follow in the place where ZnO thickness H/lambda is larger than 0.05, but a large electromechanical coupling coefficient is obtained.
[0048] In addition, it turns out that thickness H/lambda by which the ZnO thin film which can excite the cut angle of the Xtal radical to be

used and the surface wave to be used was standardized differs so that clearly, if the result shown in drawing 6 - drawing 8 is compared. Like the direction propagation Xtal substrate of ST cut X mentioned above, and the direction propagation Xtal substrate of 165-degree rotation Y cut X, in the case of a Rayleigh wave surface wave H/lambda -- 0.05 or more [then] and a good thing -- further -- the case of a leakage surface acoustic wave -- a 115-degree rotation Y cut X propagation Xtal substrate -- H/lambda -- 0.14 or more and a 105-degree rotation Y cut X propagation Xtal substrate -- H/lambda -- 0.05 or more -- then, it is good. Therefore, when forming a ZnO thin film on the Xtal substrate, as for thickness H/lambda by which the ZnO thin film was standardized, carrying out to 0.05 or more is desirable.

[0049] As mentioned above, since various rotation Y cuts from which an Eulerian angle differs were used as a used Xtal substrate, class creation of much above-mentioned SAW equipments using the Xtal substrate with which Eulerian angles differ was carried out. Thus, the above-mentioned Eulerian angle and electromechanical coupling coefficient K2 of SAW equipment which were obtained 0 mark is attached and relation is shown in drawing 16 (a).

[0050] In addition, as for the broken line P of a leakage surface wave, the continuous line N of drawing 16 (a) shows the electric machine engagement multiplier of the Xtal substrate of the rotation Y cut X propagation in the case of a Rayleigh wave itself. the square of the electromechanical coupling coefficient of the Rayleigh wave in the structure which 0 mark in drawing and - mark formed the ZnO film on Xtal, respectively, and formed IDT on it further, and a leakage surface acoustic wave -- value K2 It is shown. the square of the electromechanical coupling coefficient of a Rayleigh wave when ** mark and ** mark prepare a short circuit electrode in the boundary of ZnO and Xtal further on the other hand at the structure, respectively, and a leakage surface acoustic wave -- value K2 It is shown. Thus, K2 With cut angles, it changes somewhat. Moreover, drawing 16 (b) is again illustrated directly under drawing 16 (a) for the comparison with drawing 16 (a), although it is the same Fig. as drawing 10 .

[0051] Although TCD used the Xtal substrate which has the neighboring cut angle of zero in order to improve the temperature characteristic when the SAW equipment using the Xtal substrate was constituted conventionally as explained with reference to example of experiment 2 drawing 10 , a sufficiently big electromechanical coupling coefficient was not able to be obtained in this case. The invention-in-this-application person found out that good TCD and a big electromechanical

coupling coefficient could be obtained, when combining the Xtal substrate whose TCD is minus, and the ZnO thin film in the relation between the Eulerian angle shown in drawing 10 , and TCD.

[0052] In addition, in the field of minus of TCD, the relation between the cut angle of the Xtal substrate and the propagation direction, and TCD exists also in which Xtal substrate. This is explained with reference to drawing 11 - drawing 14 .

[0053] Drawing 11 shows relation with the include angles theta and TCD from the X-axis of the propagation direction in ST cut Xtal substrate, in drawing 12 , drawing 13 shows relation with the include angles theta and TCD from the X-axis of the propagation direction of Y cut Xtal substrate, and drawing 14 shows relation with the include angles theta and TCD from the X-axis of the propagation direction of Z cut Xtal substrate for relation with the include angles theta and TCD from the Y-axis of the propagation direction of an X-cut-crystal substrate. Also in these Xtal substrates, that the field where TCD is subtracted exists changes by changing the propagation vectorial angle theta so that clearly from drawing 11 - drawing 14 .

[0054] Invention of the 2nd of this application realizes good TCD and a big electromechanical coupling coefficient, when the above TCD(s) combine the piezo-electric thin film in which the value of TCD's plus of the Xtal substrate of the cut angle which shows the value of minus, or the propagation direction is shown. The Xtal substrate which consists this of a rotation Y cut is taken for an example, and it explains with reference to drawing 15 .

[0055] First, the substrate of a diameter xof 76.2mm0.5mm dimension was prepared as a Xtal substrate. In addition, as this Xtal substrate, two kinds, 165-degree rotation Y cut X propagation and ST cut 35 degree propagation, were prepared.

[0056] The ZnO film was formed by the thickness to H/lambda =0-0.5 on the above-mentioned Xtal substrate, and IDT was formed so that it might be further in agreement in the above-mentioned propagation direction on it. The SAW measured the temperature characteristic (temperature 15, three 25 or 35-degree C points) of the time delay of a property. The result is shown in drawing 15 . By 165-degree rotation Y cut X propagation, it turns out by ST cut 35 degree propagation that it becomes TCD=0 about ZnO thickness H/lambda =0.16 about H/lambda =0.35. Moreover, the electromechanical coupling coefficient in this thickness shows a large value as mentioned above. That is, in 165-degree rotation Y cut X propagation, they are the former and an electromechanical coupling coefficient K2. When what was TCD=-30ppm/degree C formed the

ZnO film and IDT of H/lambda =0.35 in the Xtal substrate 0.2%, 5 times [over the past] as many K2 =1.04% as this and TCD=0ppm/degree C were obtained. Moreover, by preparing a short circuit electrode between the ZnO film and the Xtal substrate, it becomes TCD=0ppm/degree C and is K2. 1.35 still larger% is obtained.

[0057] On the other hand, it is K2 when the former and that they were K2 =0.14% and TCD=-20ppm/degree C form the ZnO film and IDT of H/lambda =0.16 on the Xtal substrate also in ST cut 35 degree propagation. 4.8 times as many K2 =0.77% as this and TCD=0ppm/degree C are obtained. Moreover, if a short circuit electrode is prepared between the ZnO film and the Xtal substrate, K2 =0.89% and TCD=0ppm/degree C will be obtained further.

[0058] Therefore, though TCD has the value of minus in that case as a Xtal substrate using the Xtal substrate of an Eulerian angle with a big electromechanical coupling coefficient so that clearly from this example of an experiment By forming the ZnO thin film in which TCD of the plus which may offset the value of minus of TCD of the Xtal substrate as a ZnO thin film is shown, and forming IDT on it shows that the SAW equipment which has a very big electromechanical coupling coefficient and the good temperature characteristic can be constituted.

[0059] Although the above-mentioned explanation explained two kinds of substrates, when a rotation Y cut and the Xtal substrate of other cut angles shown in drawing 11 - drawing 14 are used, even if TCD is minus, by using the Xtal substrate of an Eulerian angle with a big electromechanical coupling coefficient shows similarly that surface wave [with a large and electromechanical coupling coefficient] equipment with the good temperature characteristic can be constituted. That is, as shown in drawing 10 , in the Rayleigh wave in rotation Y cut X propagation, it is the range of minus [Eulerian angle (0, 0, 0) - (0, 20, 0), - (0, 45, 0) (0 65, 0) - (0, 135, 0) (0 180, 0) the range] of TCD in an Eulerian angle (0, 0, 0) - (0, 135, 0) range, and leakage surface wave. the case where ST cut Xtal substrate is used as shown in drawing 11 -- from an Eulerian angle (5 0,132. 75**0) -- (-- between 0,132.75**5 and 50) -- and (0,132. 75**5,130) -- from -- TCD is in the range of minus between (0,132.75**5,180).

[0060] Moreover, in the rotation X-cut-crystal substrate, TCD is [the Eulerian angle] subtracted between the range of - (90, 90, 0) (90, 90, 35), and (90 90,145) - (90 90,180) so that clearly from drawing 12 .

[0061] Similarly, in the rotation Y cut Xtal substrate, TCD is [the Eulerian angle] subtracted between (0, 90, 0), and (0, 90, 35) and (0 90,145) between - (0 90,180) as shown in drawing 13 . Moreover, with Z

cut Xtal substrate, when phi of an Eulerian angle (0, 0, phi) is the propagation directions other than 0, 60, 120, and 180, the value of TCD is the value of minus, so that clearly from drawing 14 .
[0062] Therefore, surface wave [with a large and electromechanical coupling coefficient] equipment with the good temperature characteristic can be constituted like the above by forming in the top face of each Xtal substrate the ZnO thin film which has the TCD value of plus, and forming IDT further so that the large cut angle of an electromechanical coupling coefficient may be chosen also in the range in the range mentioned above although each Xtal substrate shows the value of minus of TCD, and the value of minus of TCD may be offset.
[0063] Moreover, when the ingredient of a single crystal like the Xtal substrate is used, the direction of the phase-velocity vector which goes to IDT from IDT, and the propagation direction of actual energy may stop being in agreement with the anisotropy of that cut angle, this phenomenon is called power flow, and the include angle produced at this time is called power flow angle. When this power flow is taken into consideration, a power flow angle is 0 and the cut angle of the Xtal substrate [as / whose angle as TCD indicates the value of minus to be to coincidence is 0] is desirable. This desirable cut angle An Eulerian angle (0, 25, 0) - (0, 105, 0) between, Between - (0, 45, 35), - (0, 10, 60) (0, 20, 70) between, (0, 0, 15) Between - (0, 180, 45) - (0, 0, 85) (0, 0, 90) between, (0, 90, 30) (90, 90, 25) It is between - (90, 90, 31) - (0, 90, -3) (0, 90, 3) in between, and TCD is minus in this case, and a power flow angle is 0.
[0064] Therefore, by forming a ZnO thin film on each Xtal substrate in the range mentioned above, and forming IDT further, the temperature characteristic is greatly good and an electromechanical coupling coefficient can constitute the surface wave equipment which does not have a bias in the propagation direction.
[0065] In addition, although the above-mentioned example of an experiment explained the case where a ZnO thin film was formed as a piezo-electric thin film, the proper piezo-electric thin film which has the TCD value of pluses, such as AlN and Ta 2O5 besides a ZnO thin film, and CdS, may be used.
[0066] Furthermore, about the Xtal substrate, it points out that any of a plus side and a minus side may be used.
[0067]
[Effect of the Invention] As mentioned above, in invention of the 1st of this application, the sinking comb electrode is formed on the piezo-electric thin film formed on the Xtal substrate, and since

standardization thickness H/lambda of a piezo-electric thin film is made or more into 0.05, the surface wave equipment with which a big electromechanical coupling coefficient is obtained can be offered. That is, it becomes possible to raise an electromechanical coupling coefficient by leaps and bounds compared with the structure in which the sinking comb electrode was formed, between the Xtal substrates and the piezo-electric thin films which were presupposed that a big electromechanical coupling coefficient can be obtained conventionally.
[0068] Moreover, according to invention of the 2nd of this application, the Xtal substrate of the cut angle in which TCD has the value of minus as a Xtal substrate, and the propagation direction is used, and the piezo-electric thin film is formed on this Xtal substrate. Therefore, since a piezo-electric thin film has the TCD value of usually plus, the TCD value of the Xtal substrate is offset by the TCD value of a piezo-electric thin film, and the good surface wave equipment of the temperature characteristic can be obtained. Therefore, even if a TCD value is minus, by using the Xtal substrate of the large cut angle of an electromechanical coupling coefficient, and the propagation direction, the temperature characteristic which was not able to be realized conventionally is good and it becomes possible to offer the surface wave equipment which has an electromechanical coupling coefficient big moreover.

[Translation done.]

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] (a) And (b) is each sectional view showing the glass substrate in conventional surface wave equipment, a piezo-electric thin film, and the laminated structure of IDT, respectively.

[Drawing 2] (a) And (b) is each sectional view for explaining the glass substrate in conventional SAW equipment, a short circuit electrode, a piezo-electric thin film, and the laminated structure of IDT, respectively.
[Drawing 3] Thickness by which the piezo-electric thin film in the SAW equipment shown in drawing 1 and drawing 2 was standardized, and drawing showing relation with an electromechanical coupling coefficient.
[Drawing 4] (a) And set to conventional SAW equipment and (b) is LiNbO3, respectively. Structure and LiNbO3 in which a piezo-electric thin film and IDT were formed on the substrate Drawing showing the relation of the thickness and the electromechanical coupling coefficient in the structure which carried out the laminating of IDT and the piezo-electric thin film to this order on the substrate by which the ZnO thin film was standardized.
[Drawing 5] (a) And (b) is LiNbO3, respectively. Drawing showing the relation of the thickness and the electromechanical coupling coefficient by which the ZnO thin film at the time of forming in a location which is different in IDT and a short circuit electrode in the surface wave substrate which comes to form a ZnO thin film on a substrate was standardized.
[Drawing 6] Drawing showing the relation of the thickness and the electromechanical coupling coefficient by which the ZnO thin film of three kinds of surface wave equipments in which the piezo-electric thin film and the sinking comb electrode were formed on ST cut Xtal substrate was standardized.
[Drawing 7] Drawing showing the relation of the thickness and the electromechanical coupling coefficient by which the ZnO thin film of the surface wave equipment of three kinds of structures in which the ZnO thin film and the sinking comb electrode were formed on the direction propagation Xtal substrate of 165-degree rotation Y cut X was standardized.
[Drawing 8] Drawing showing the relation of the thickness and the electromechanical coupling coefficient by which the ZnO thin film in the surface wave equipment which constituted the ZnO thin film and the sinking comb electrode in various gestalten on the Xtal substrate which consists of a 115-degree rotation Y cut was standardized.
[Drawing 9] (a) And (b) is a partial notching sectional view of a part in which the typical top view and sinking comb electrode of SAW equipment which are constituted as the example of reference and 1 operation gestalt of this invention are formed.
[Drawing 10] Drawing showing relation with the Eulerian angle, TCD, and

the propagation loss in a rotation Y cut Xtal substrate.
[Drawing 11] Drawing showing the relation of the propagation direction and TCD in ST cut Xtal substrate.
[Drawing 12] Drawing showing the relation between the propagation direction of an X-cut-crystal substrate, and TCD.
[Drawing 13] Drawing showing the relation between the propagation direction of Y cut Xtal substrate, and TCD.
[Drawing 14] Drawing showing the relation between the propagation direction of Z cut Xtal substrate, and TCD.
[Drawing 15] Drawing showing the relation between the ZnO thickness at the time of using 165-degree rotation Y cut X propagation and an ST cut 35 degree propagation Xtal substrate, and TCD.
[Drawing 16] (a) And (b) is drawing showing the relation of the Eulerian angle of a rotation Y cut Xtal substrate and electromechanical coupling coefficient in the operation gestalt of invention of the 2nd of this application, and drawing showing the relation between an Eulerian angle, TCD, and a propagation loss in a list, respectively.
[Description of Notations]
10 -- Xtal substrate 11
 -- SAW equipment
12 -- ZnO thin film
13 14 -- IDT
13a, 13b, 14a, 14b -- Sinking comb electrode

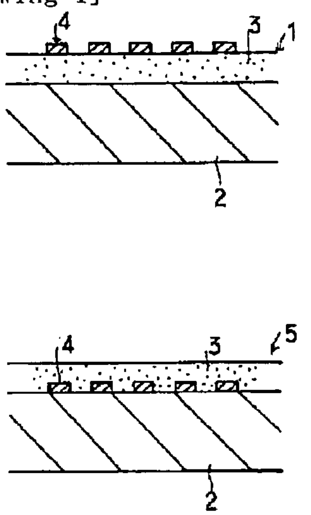
[Translation done.]

DRAWINGS

[Drawing 1]

(a)

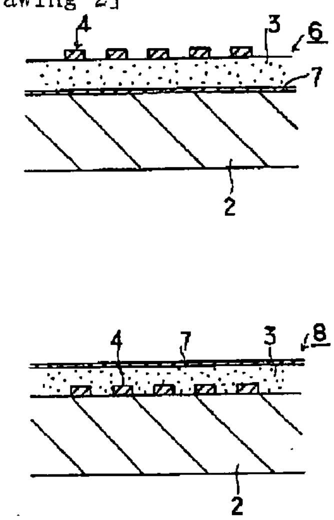
(b)



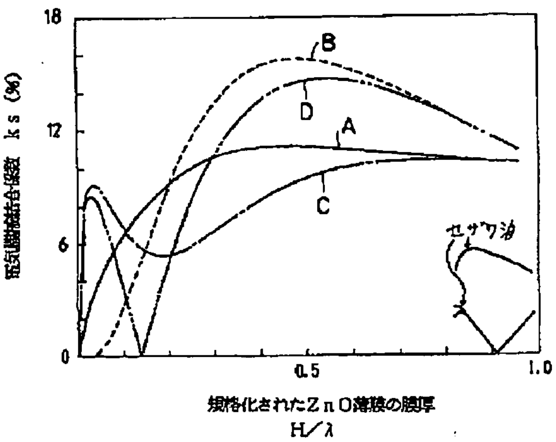
[Drawing 2]

(a)

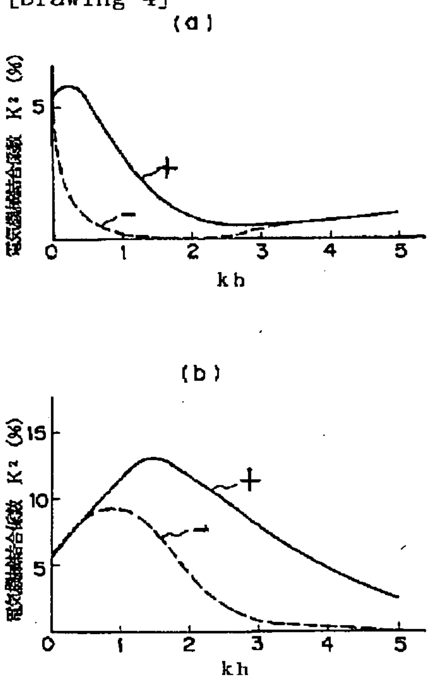
(b)



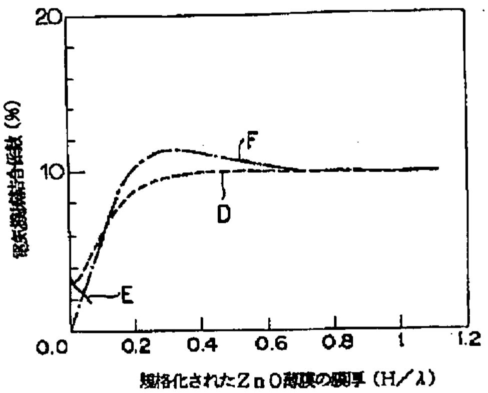
[Drawing 3]



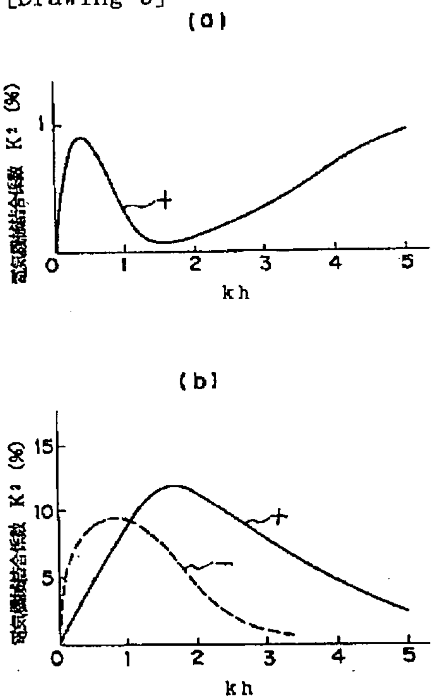
[Drawing 4]



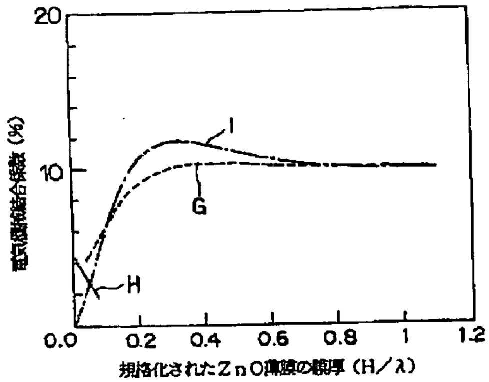
[Drawing 6]



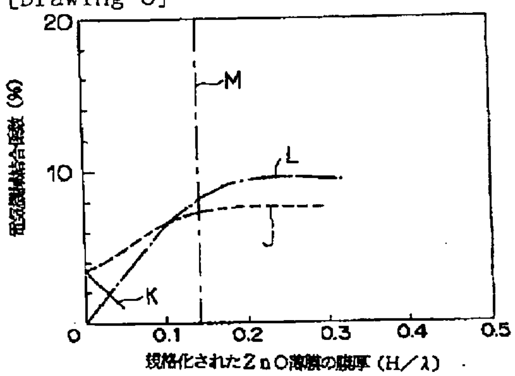
[Drawing 5]



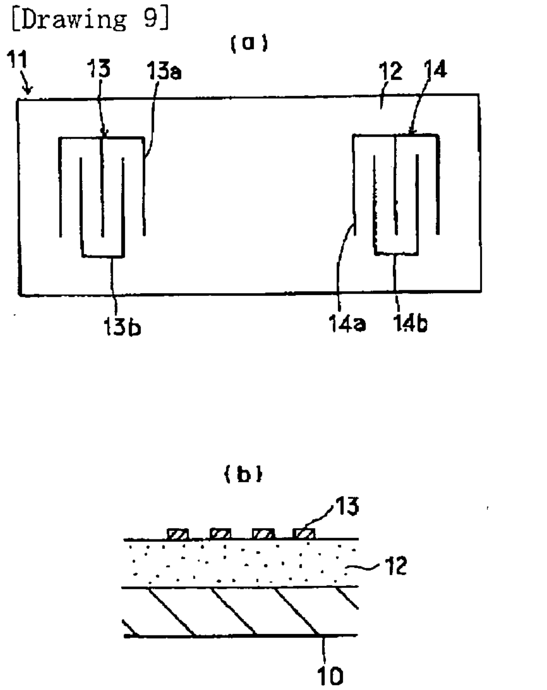
[Drawing 7]



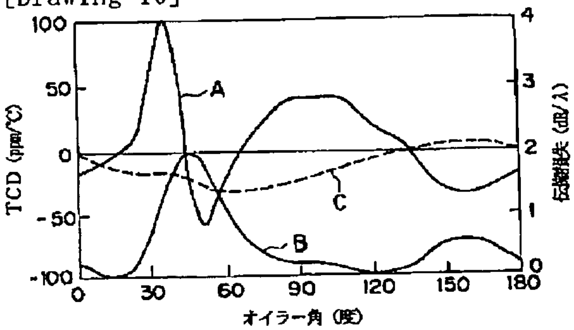
[Drawing 8]



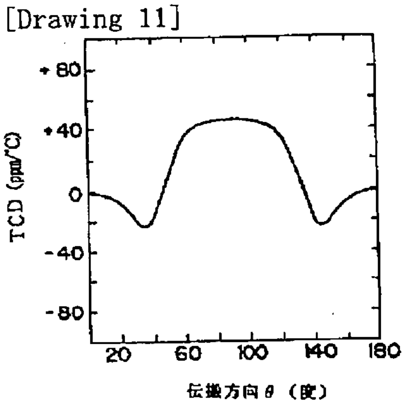
[Drawing 9]



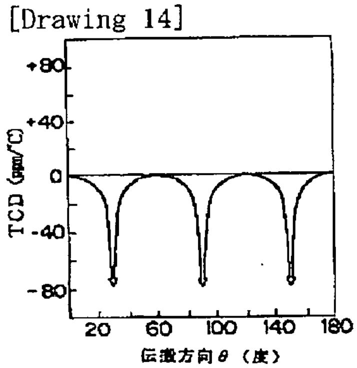
[Drawing 10]



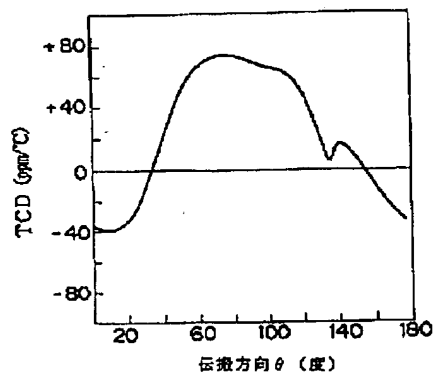
[Drawing 11]



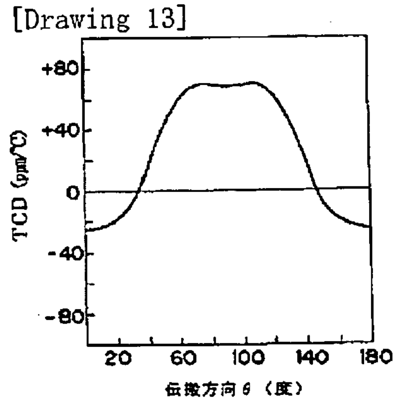
[Drawing 14]



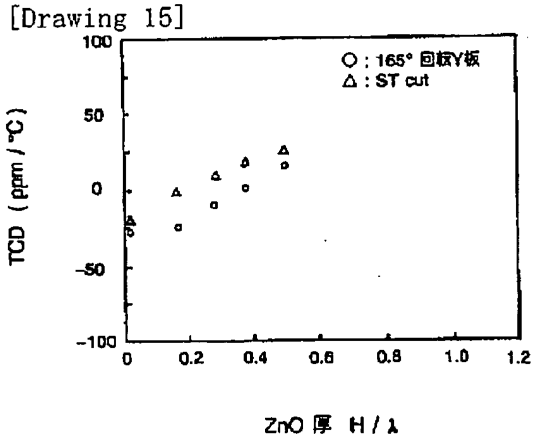
[Drawing 12]



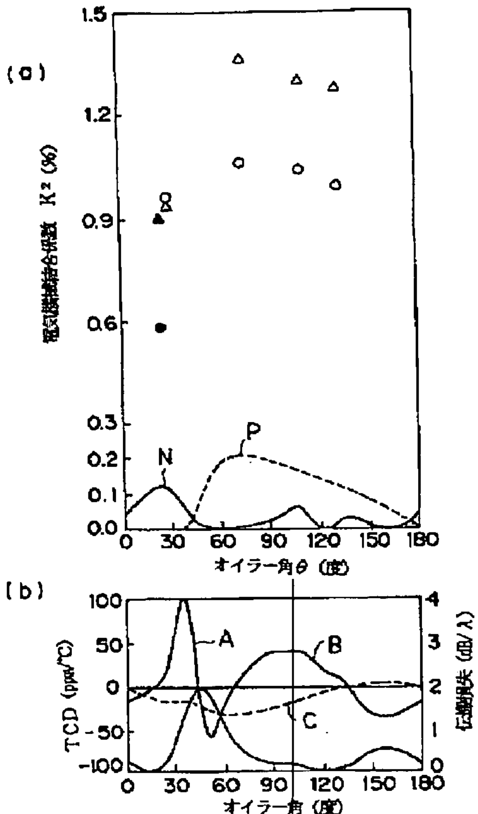
[Drawing 13]



[Drawing 15]



[Drawing 16]



[Translation done.]